



# Rapid Response tools and datasets for post-fire modeling applied to the Horse River Fire in Fort McMurray

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USFS Rocky Mt Research Station, Moscow, ID

*Collaborator:*

Lee MacDonald, Colorado State University

**NASA Applied Sciences Program for Wildfires Grant  
#NNX12AQ89G**

# Introduction

- Forests provide many products as well as ecosystem services
  - Wood
  - Wildlife and fish habitat
  - Recreation
  - Clean water
- Wildfire impacts on watersheds
  - Increased peak flow rates (up to 100x)
  - Increased sediment delivery to streams (up to 1000x)



Forest in Northern Idaho



Waiting for the flood after an Arizona fire

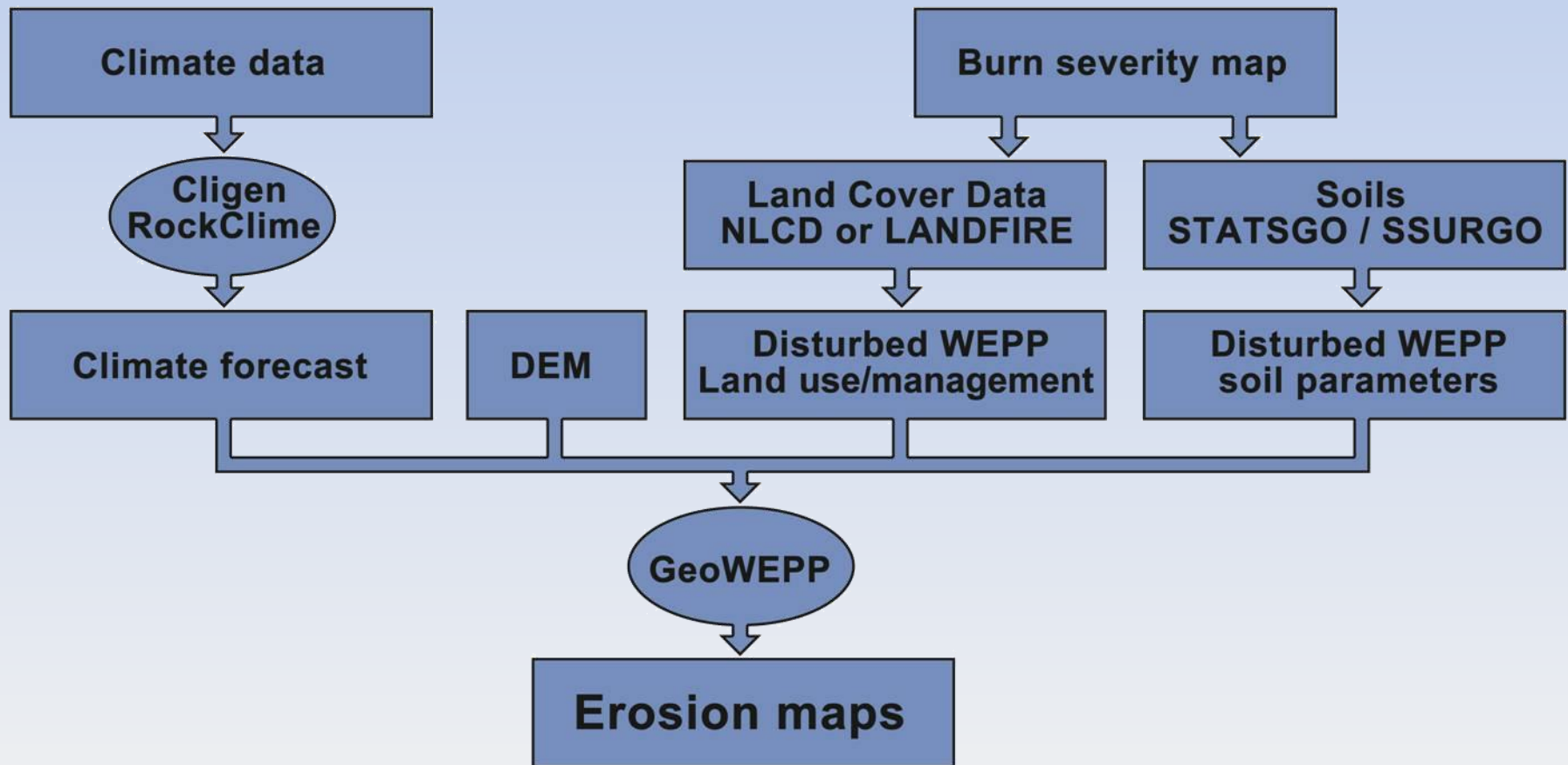
# BAER Teams

## (Burned Area Emergency Response)

- Mission: Protect lives, property and natural resources threatened by post-fire flooding and erosion.
- BAER Teams go to work before the fire is out.
- Treatments need to be completed before a major storm in order to be effective.



# WEPP (Water Erosion Prediction Project) Watershed Erosion Model

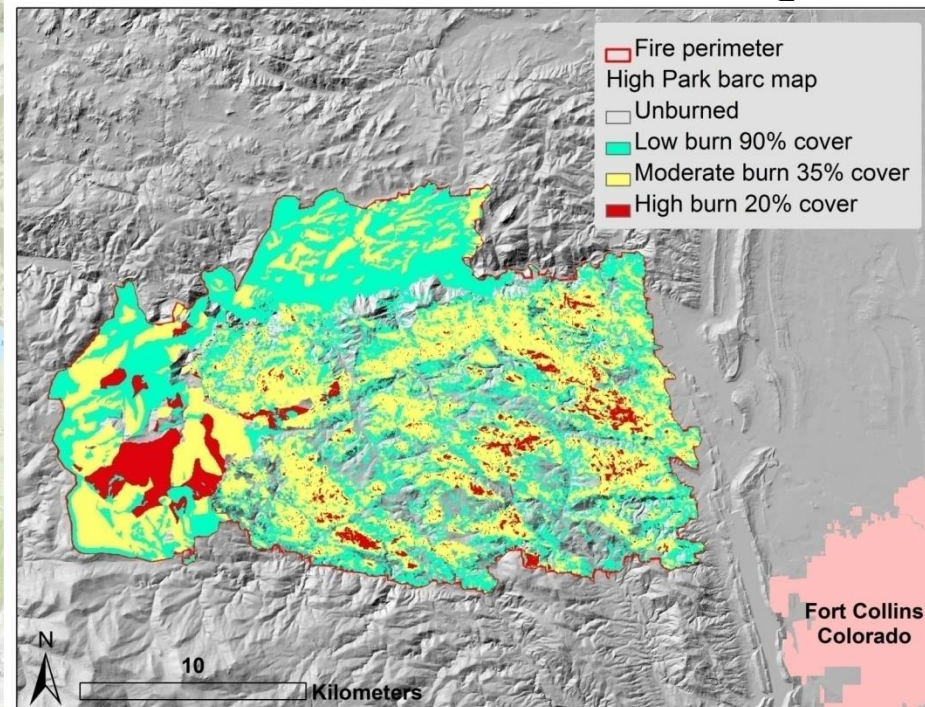
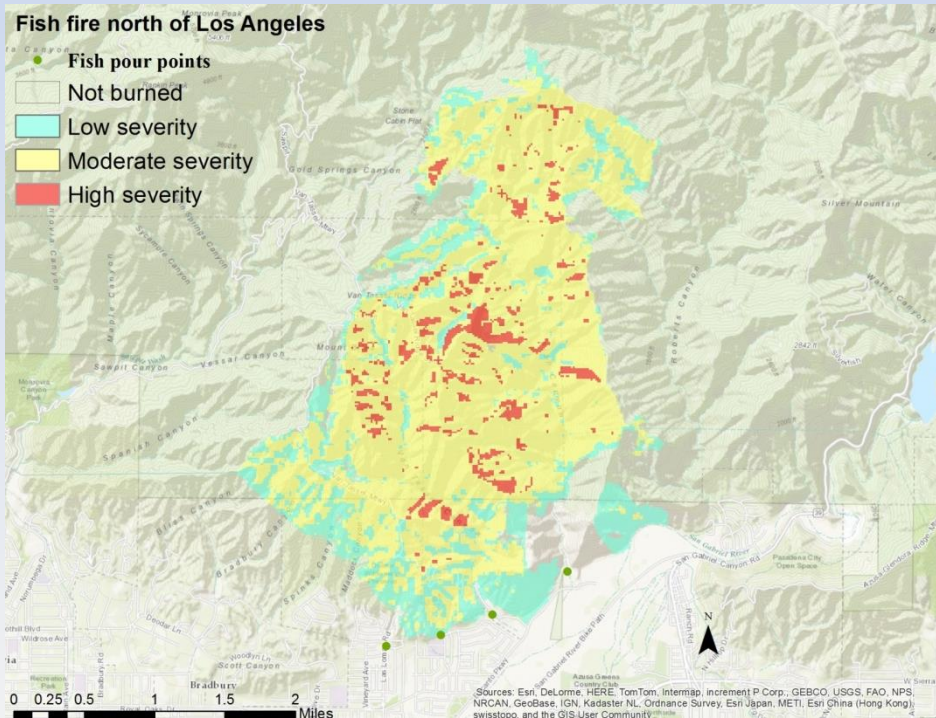


# Remote Sensing Data

$$\text{NBR} = (\text{R}_{\text{NIR}} - \text{R}_{\text{SWIR}}) / (\text{R}_{\text{NIR}} + \text{R}_{\text{SWIR}})$$

Where: R is the reflectance at the satellite in either the near-infrared (NIR) or the shortwave-infrared (SWIR). The change in NBR between the pre- and post-fire conditions is calculated by:

$$\text{dNBR} = \text{NBR}_{\text{prefire}} - \text{NBR}_{\text{postfire}}$$



# Problem - Spatial process based erosion models are currently under utilized.

## Rock House Fire

Date: April 9, 2011

Location: Fort Davis, TX

Size: 314,444 acres ; 127,250 ha

Hospital Canyon: 536 acres; 217 ha

BAER Team: National Park Service

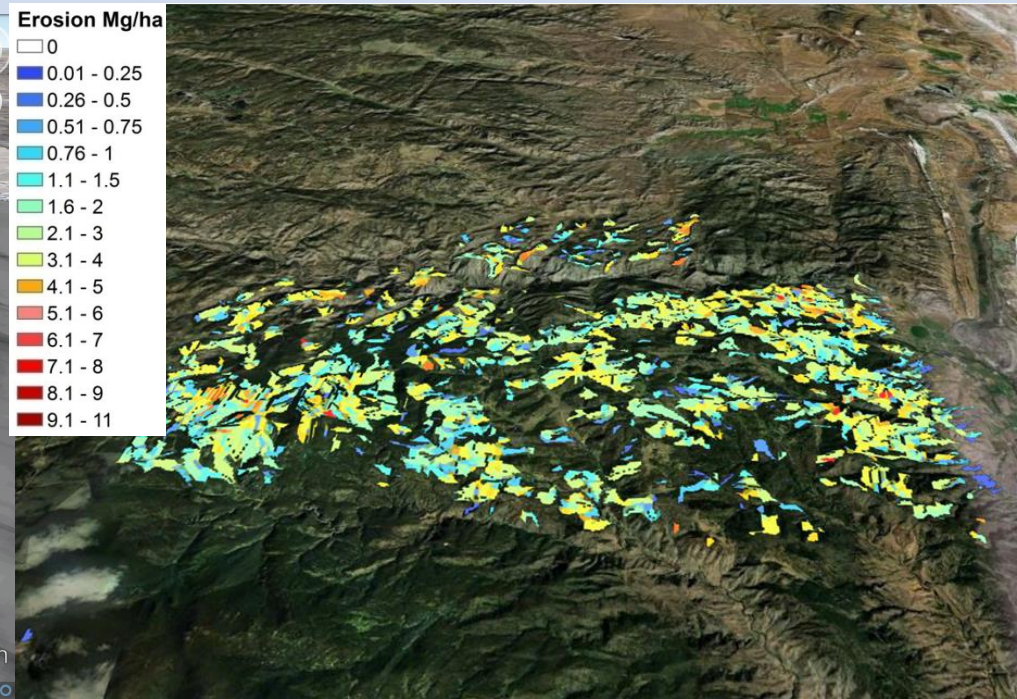
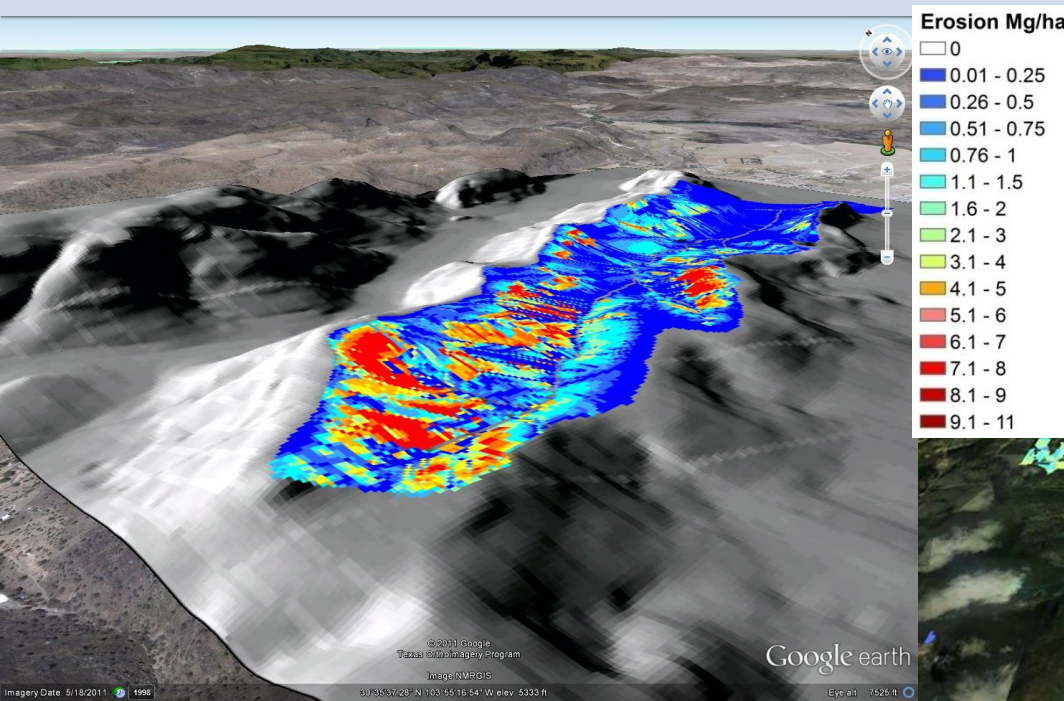
## High Park Fire

Date: June 9, 2012

Location: West of Fort Collins, CO

Size: 87,284 acres; 35,322 ha

BAER Team: Forest Service



# http://geodjango.mtri.org/geowepp/

The screenshot shows a web browser window with the URL `geodjango.mtri.org/geowepp/`. The page has a blue header with the title "Burned Area Emergency Response" and subtitle "Spatial WEPP Model Inputs Generator". Below the header, there are two tabs: "Spatial WEPP Products" (active) and "Static Files".

The left sidebar contains several sections for configuring the map:

- Draw Burned Area Extent on the Map**: Includes a button "Draw Selection on Map".
- Or, Select an MTBS Fire**: Includes dropdowns for "Select state:" (CO), "Select year:" (2012 (16 fires)), and "Select an MTBS fire:" (HIGH\_PARK\_E). There is a checked checkbox "Burn land cover and soil layers by MTBS fire".
- Or, Use a Custom BARC Map**: Includes buttons "Upload BARC Map" and "Use My Private Key".
- Options:** Includes a checkbox "Use 10m DEM" which is unchecked.
- Products:** Includes three checked checkboxes: "Land cover and linkage files", "Soils and linkage files", and "Digital elevation model (DEM)".
- File format:** Includes a dropdown menu set to "ASCII Grid (\*.asc)".

At the bottom of the sidebar are two buttons: "Download ZIP Archive" and "Add to Download". Below these is a "Download Queue" section with an upward arrow icon.

The main map area displays a map of North America with a blue outline of the United States. The map includes labels for "United States", "Mexico", "Gulf of Mexico", "Mexico Basin", "Los Angeles", "Chicago", "New York", "Hatteras Plain", and "Mexico City". The map is overlaid with a blue outline of the burned area extent. The map is titled "Michigan Tech Research Institute" in the top right corner. The map is powered by Leaflet, with icons by Farm Fresh and tiles by Esri. The map data sources are listed at the bottom: GEBCO, NOAA, CHS, OSU, UNH, CSUMB, National Geographic, DeLorme, NAVTEQ, and Esri.

# http://geodjango.mtri.org/geowepp/

The screenshot displays the 'Burned Area Emergency Response' web application. The main interface is titled 'Spatial WEPP Model Inputs Generator' and features a sidebar with options like 'Draw Burned Area Extent on the Map' and 'Or, Select an MTBS Fire'. A modal window titled 'Upload BARC Map' is open, prompting the user to 'Select a raster file to upload' and specifying burn severity classes (Low, Moderate, High) with corresponding values (2, 3, 4). The modal also includes optional parameters for buffering and EPSG code, and a note about the 30-meter pixel requirement. The background shows a map of the Hatteras Plain area with a blue outline indicating a burned area.

**Burned Area Emergency Response**  
Spatial WEPP Model Inputs Generator

**Spatial WEPP Products** | **Static Files**

**Draw Burned Area Extent on the Map**  
Draw Selection on Map

**Or, Select an MTBS Fire**  
Select state: CO  
Select year: 2012 (16 fires)  
Select an MTBS fire: HIGH\_PARK\_E  
☒ Burn land cover and soil layers by MTBS fire

**Or, Use a Custom BARC Map**  
Upload BARC Map | Use My Private Key

**Options:**  
☐ Use 10m DEM

**Products:**  
☒ Land cover and linkage files  
☒ Soils and linkage files  
☒ Digital elevation model (DEM)

**File format:** ASCII Grid (\*.asc)

**Download ZIP Archive** | **Add to Download**

**Download Queue**

**Upload BARC Map**

Select a raster file to upload:

Specify the values of **burn severity classes** in the uploaded raster. Any value that is not **Low**, **Moderate**, or **High** will be reclassified as **Unburned**:

Low: 2  
Moderate: 3  
High: 4

**Optional parameters:**  
☐ Buffer my burned area by 10 pixels  
☐ EPSG code (SRID):

**For best results, your BARC map should have 30-meter pixels.** BARC maps with a pixel size other than 30 meters will be resampled to 30 meters, which may result in misalignment of the output data compared to the original BARC map.

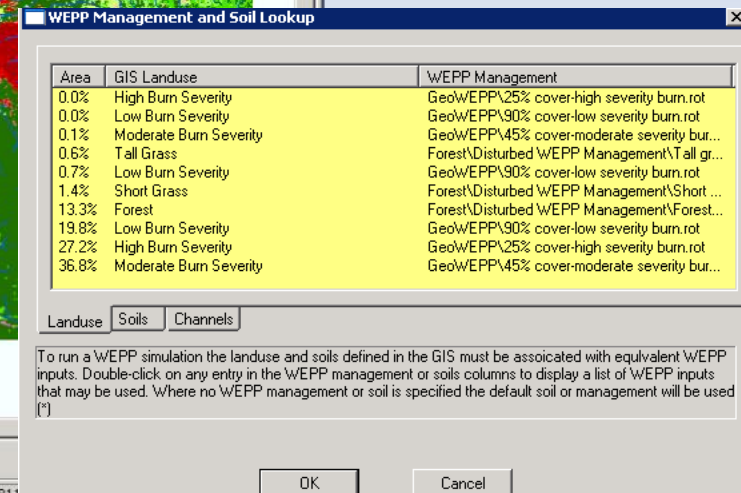
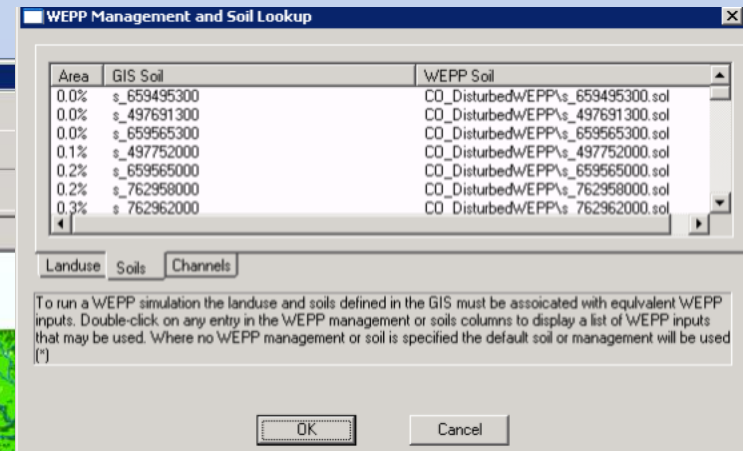
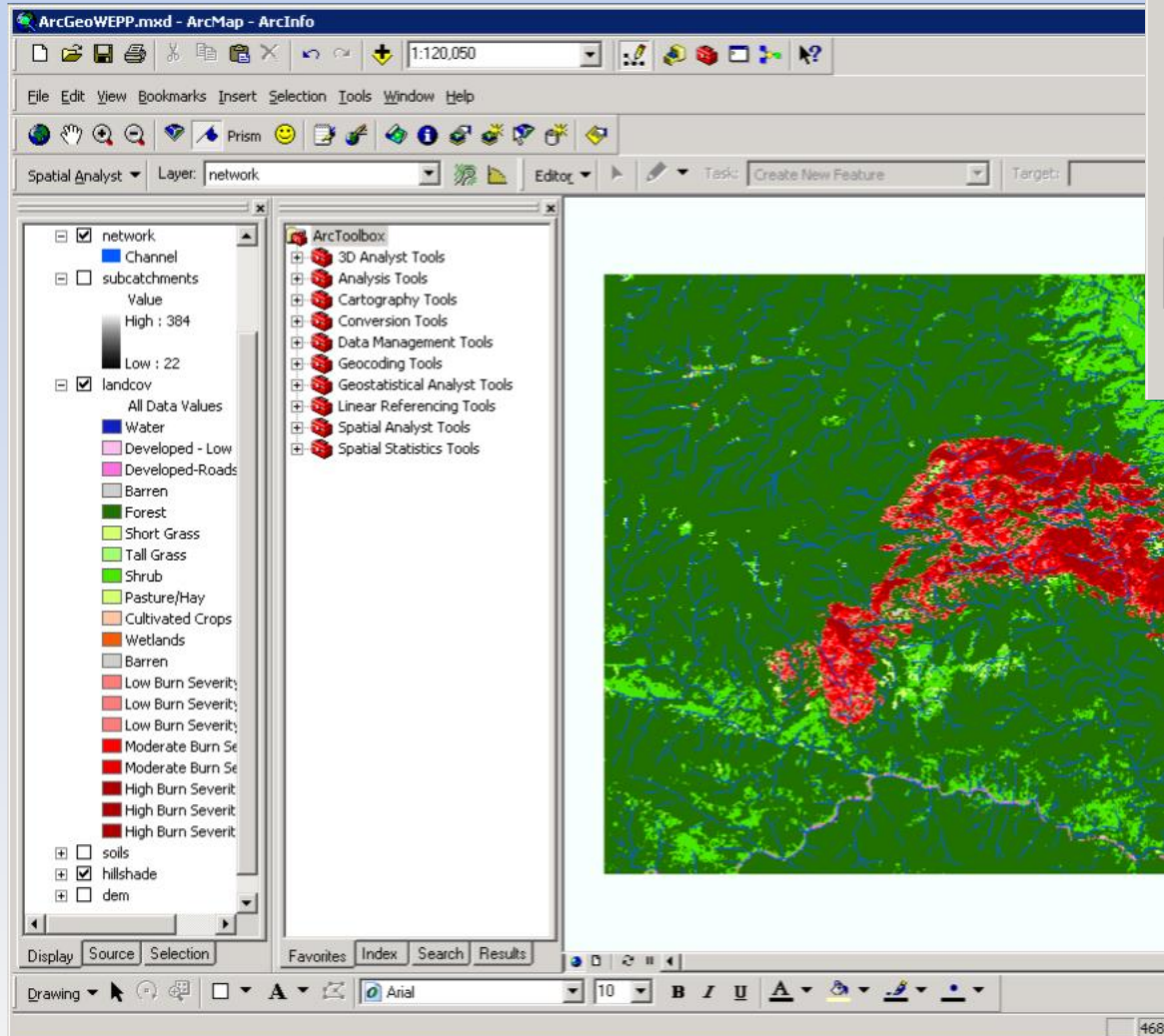
A private key will be generated which grants you future access to your uploaded data. Only this key can be used to access the BARC map you uploaded and it will expire, along with your uploaded data, after 14 days. Within that time, use this key instead of uploading the file again.

**Cancel** | **Upload**

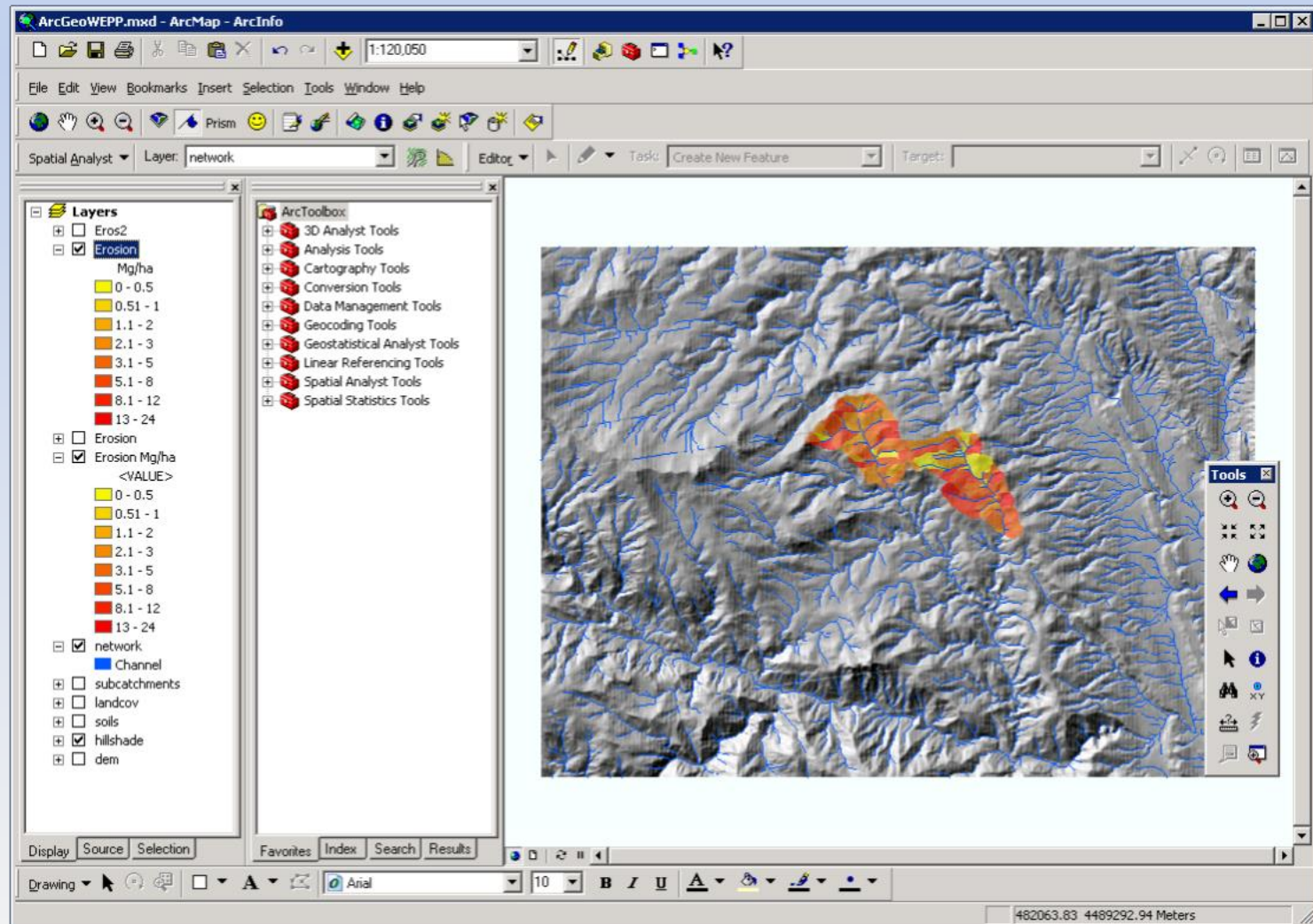
Michigan Tech Research Institute

Leaflet | Icons by Farm Fresh | Tiles © Esri — Sources: GEBCO, NOAA, CHS, OSU, UNH, CSUMB, National Geographic, DeLorme, NAVTEQ, and Esri

# NASA BAER database creates WEPP linkage files!



# BAER Teams can focus on modeling!



# NASA BAER in Action!

## for **Fuels Planning**

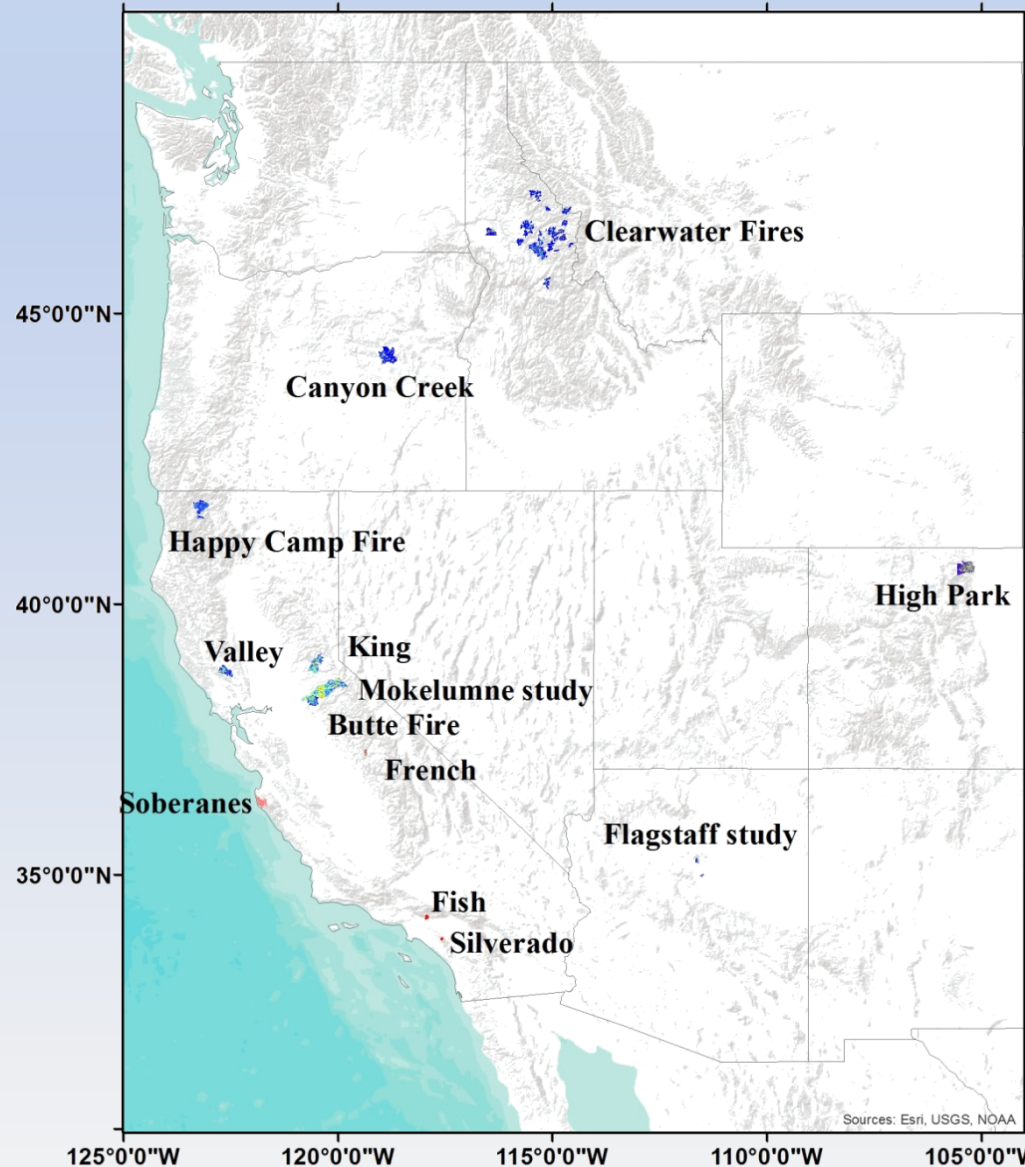
- Mokelumne
- Flagstaff

## for **BAER Teams**

- Canyon Creek, OR
- Clearwater, ID
- Butte, CA
- Valley, CA
- French, CA
- Happy Camp, CA
- Silverado, CA
- King, CA
- Soberanes, CA
- Fish, CA
- Cedar, CA

## for **Validation study**

- High Park, CO



# End User Feedback



*"For me, your erosion modeling and its use in analysis of treatment effects was the most necessary part of our mulch treatment decision-making process."*

Jeff TenPas, Regional Soil Scientist and BAER Coordinator  
USDA Forest Service – Pacific Southwest Region (R5)

*"Your WEPP research was a key input for the "Watershed Clearinghouse," a joint FEMA-State technical services group."* Mary M Shaw FEMA  
Emergency Management Planner

*We have three erosion control projects either underway or soon to begin:*

- *"Our \$3 million Wood Shred contract is out for bid, and I expect a contractor will be selected by the end of next week."*

Bill Haigh, Mother Lode Field Manager, BLM

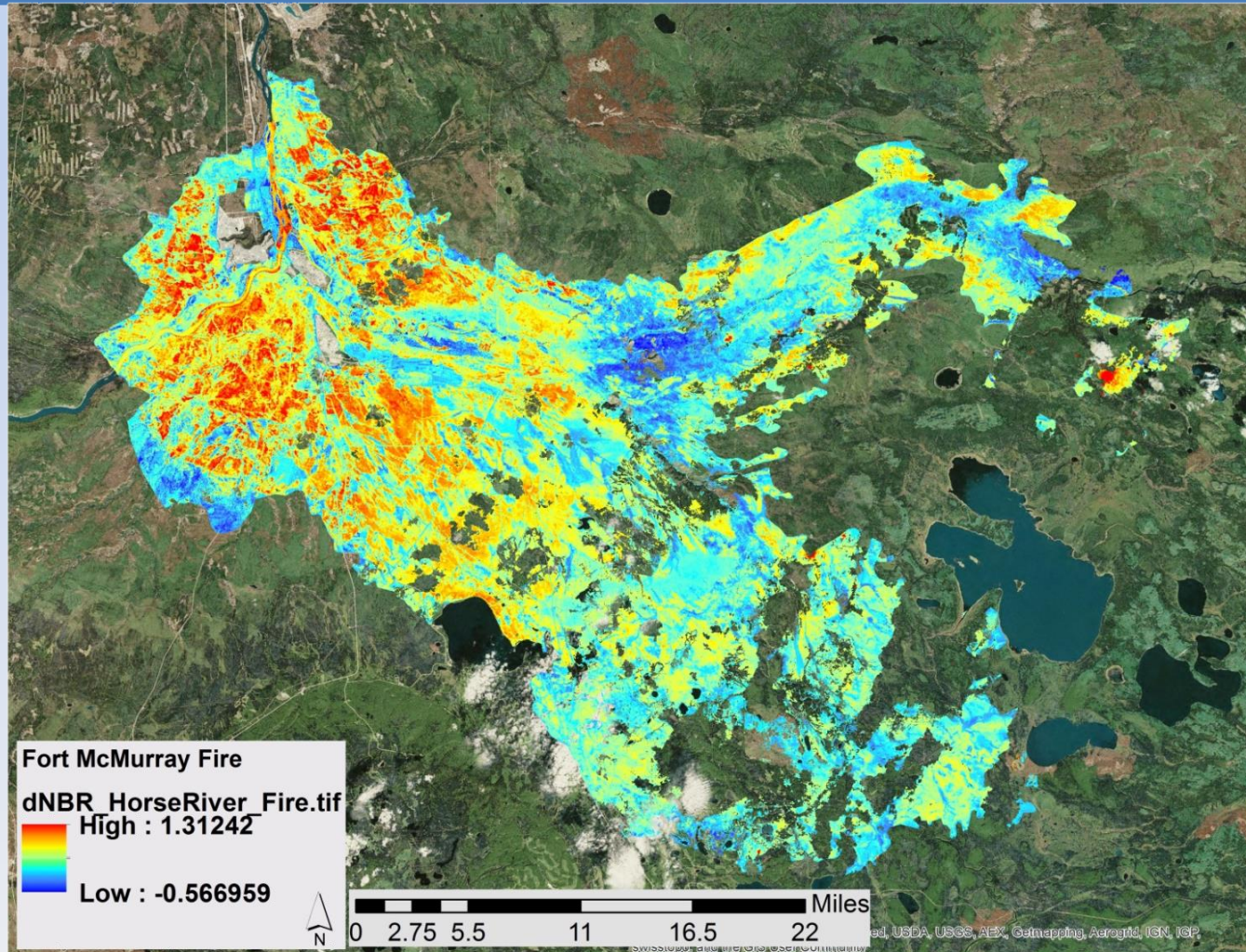
*Thank you very much, Mary! Super data; this will be extremely helpful. We are starting BARC checking in earnest today.*

Pete Cafferata- Watershed Protection Program Manager, Forester III  
California Department of Forestry and Fire Protection

# Horse River Fire in Fort McMurray

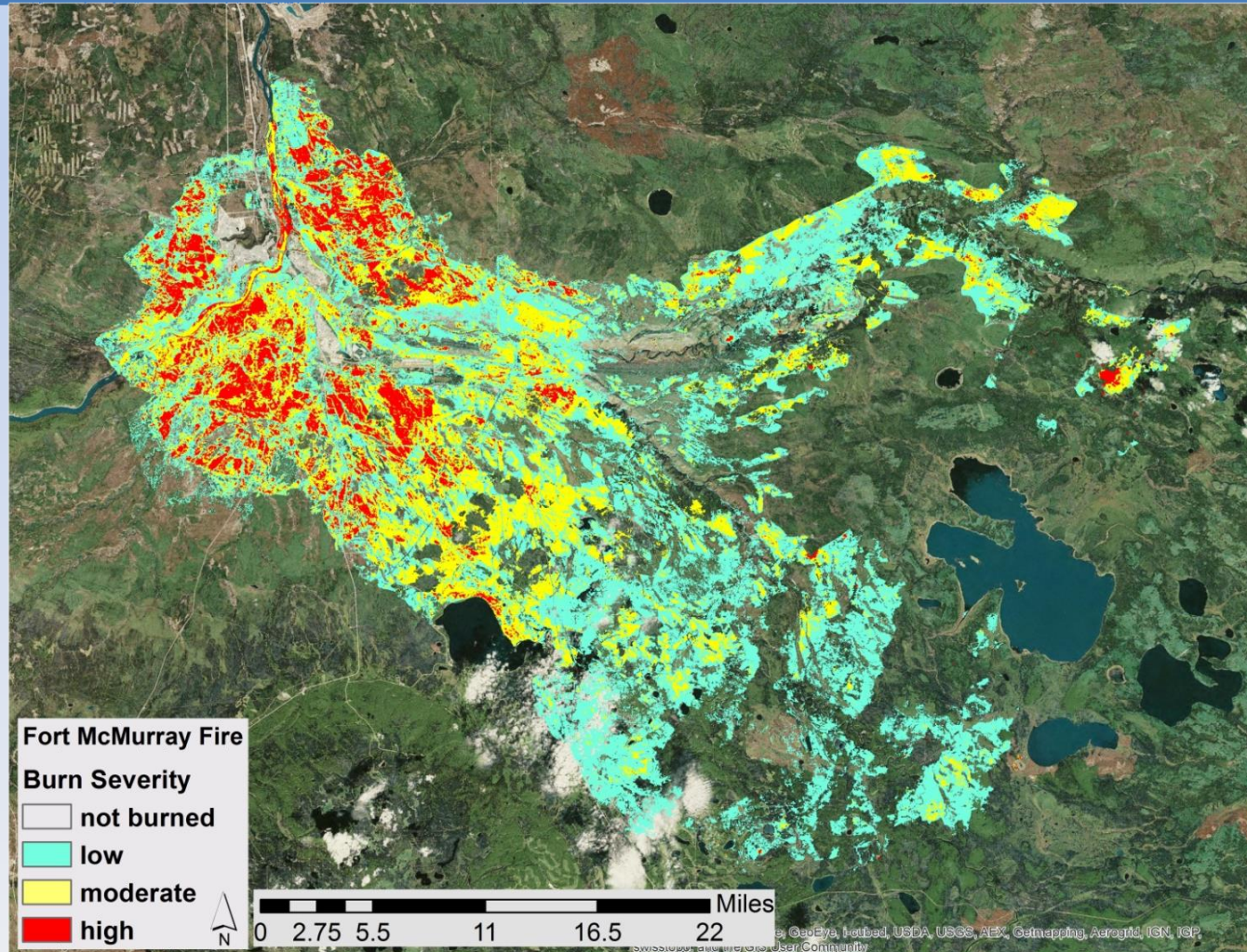
- Horse River Fire burned through the town of Fort McMurray destroying 10% of the town
- largest wildfire evacuation in Alberta's history
- Burned from May 1 – July 5, 2016
- 590,000 hectares (1,500,000 acres)
- We coordinated our BAER response with:  
François-Nicolas Robinne - Western  
Partnership for Wildland Fire Science  
Department of Renewable Resources

# RECOVER project dNBR map



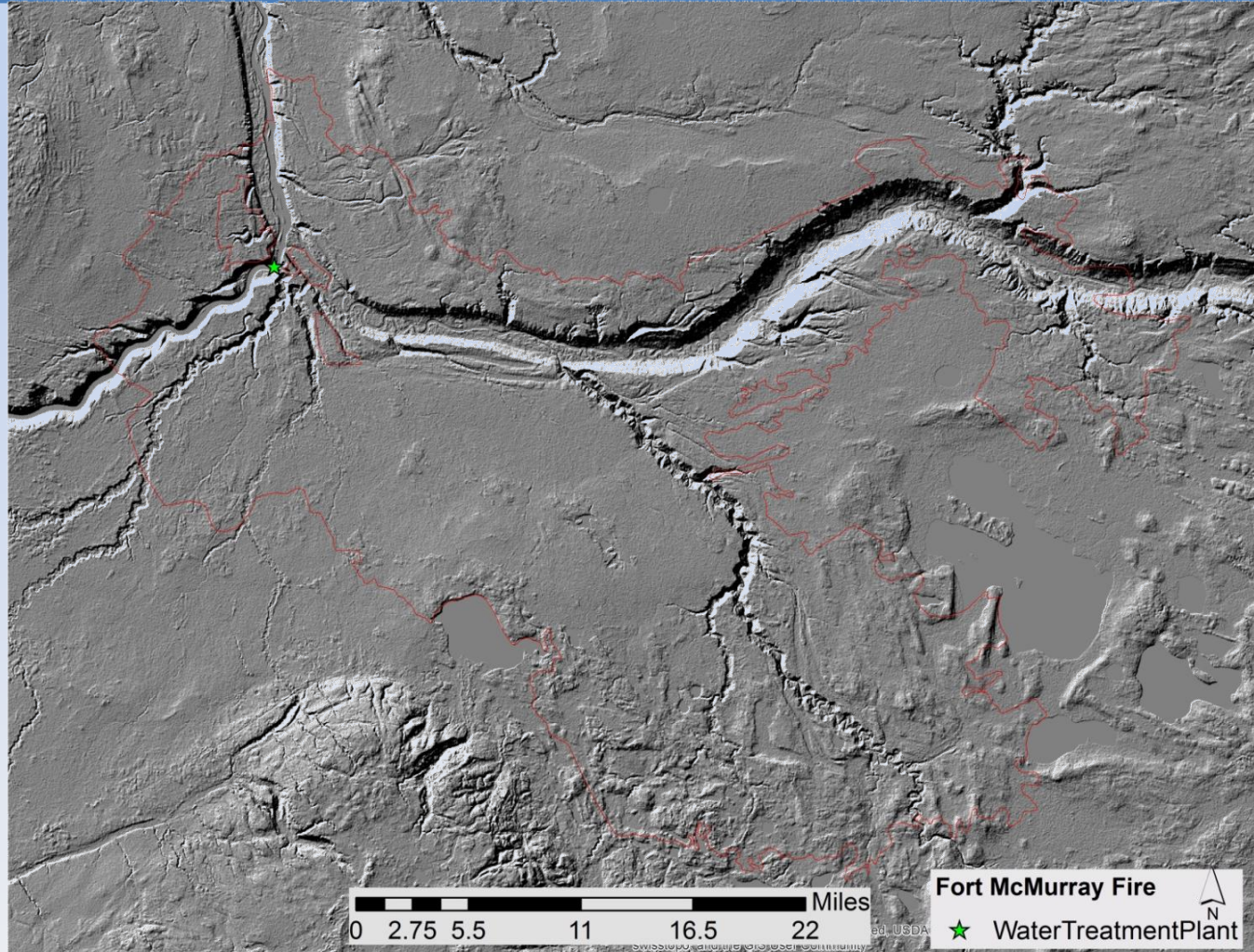
Schnase, John L., M. L. Carroll, K. T. Weber, Molly E. Brown, Roger L. Gill, Margaret Wooten, J. May et al.  
"RECOVER: An Automated, Cloud-Based Decision Support System for Post-Fire Rehabilitation Planning."  
*The International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences* 40, no. 1 (2014): 363.

# Classified Burn Severity



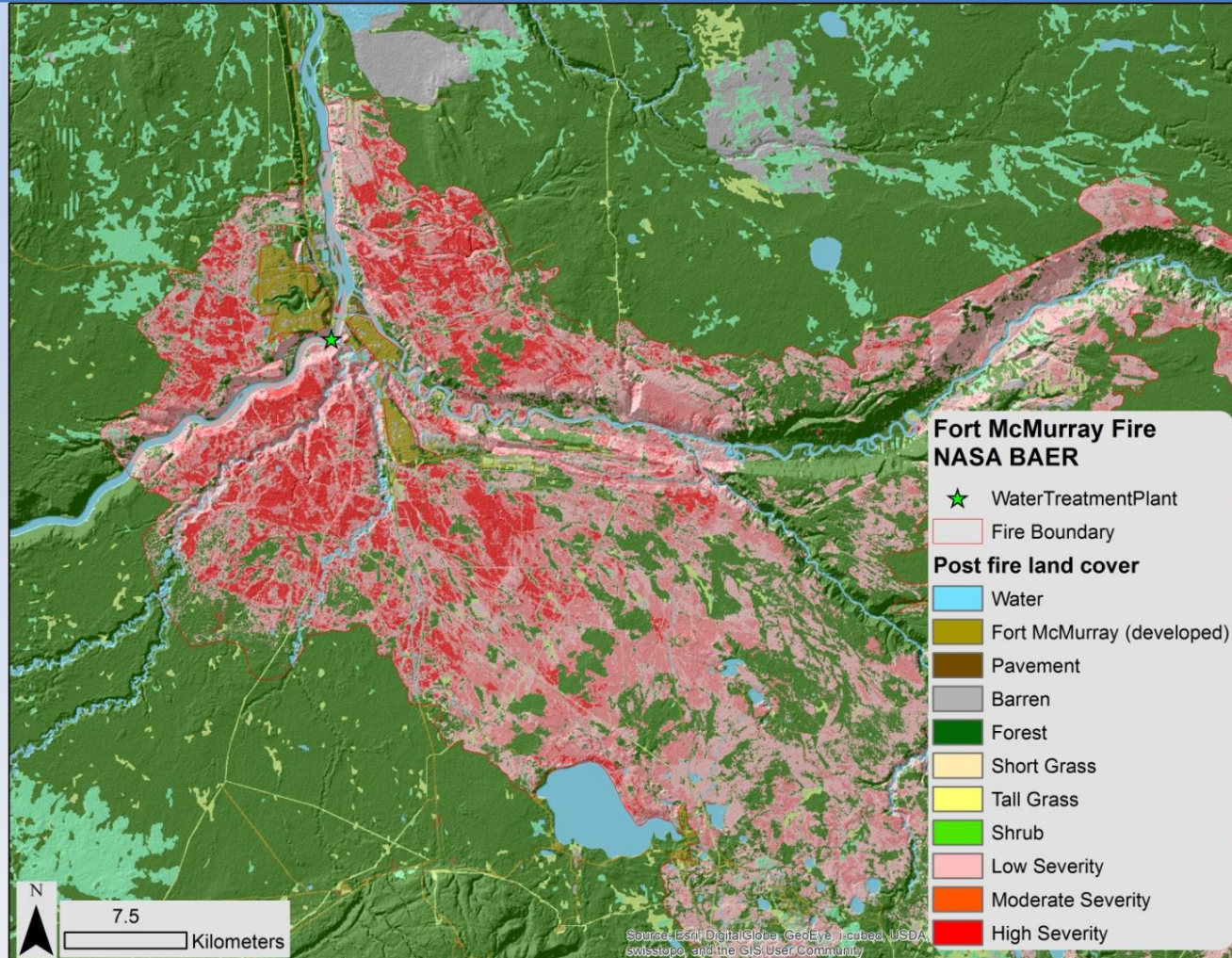
Hall, R. J., Freeburn, J. T., De Groot, W. J., Pritchard, J. M., Lynham, T. J., & Landry, R. (2008). Remote sensing of burn severity: experience from western Canada boreal fires. *International Journal of Wildland Fire*, 17(4), 476-489.

# DEM



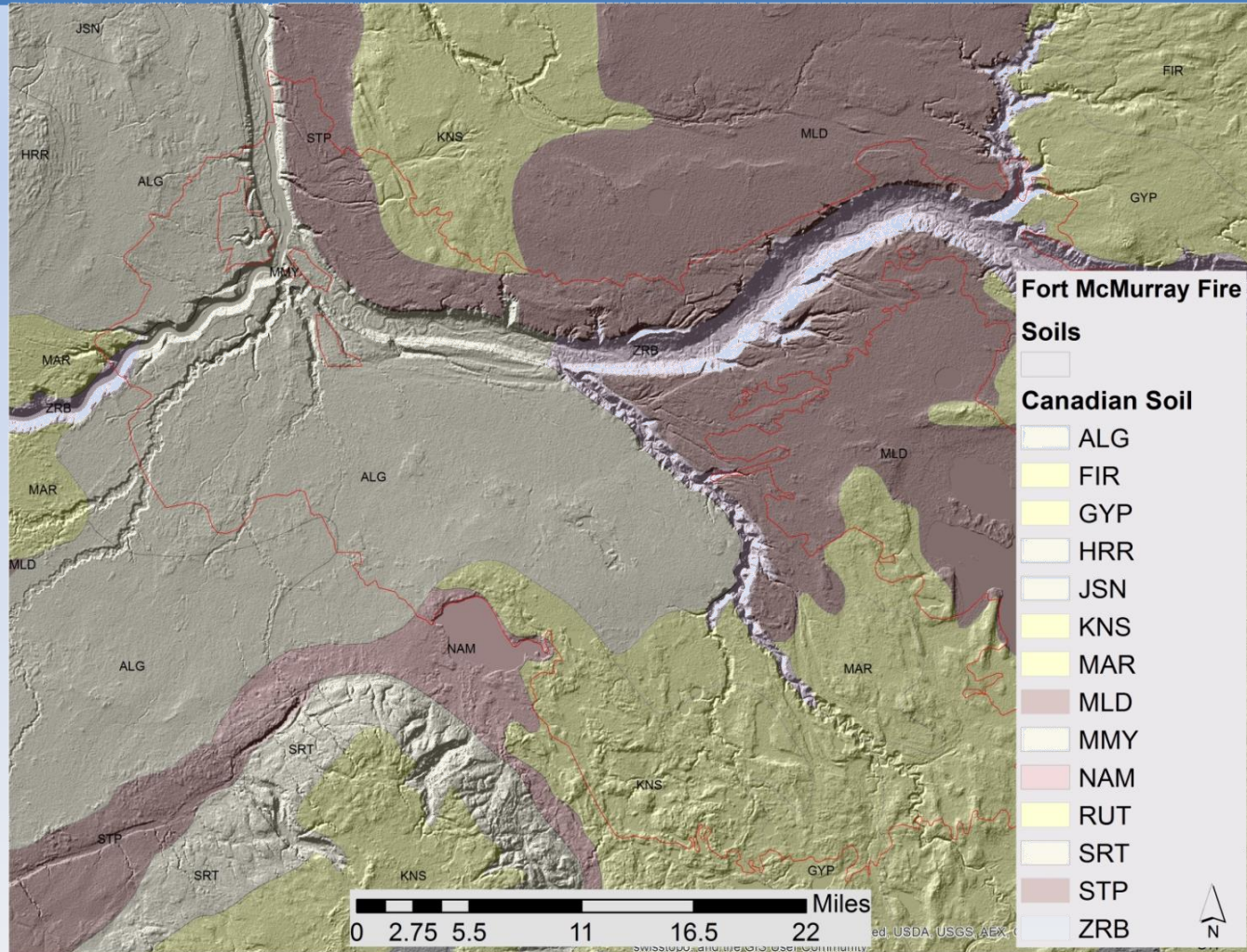
DEM data at a spatial resolution of 10 meters was made available to us through our Canadian colleague, François-Nicolas Robinne.

# Post-fire Land Cover



Alberta Biodiversity Monitoring Institute land cover map Low 85%. Mod 60%, High 25%  
(<http://www.abmi.ca/home/data/gis-data/land-cover-inventory.html>)

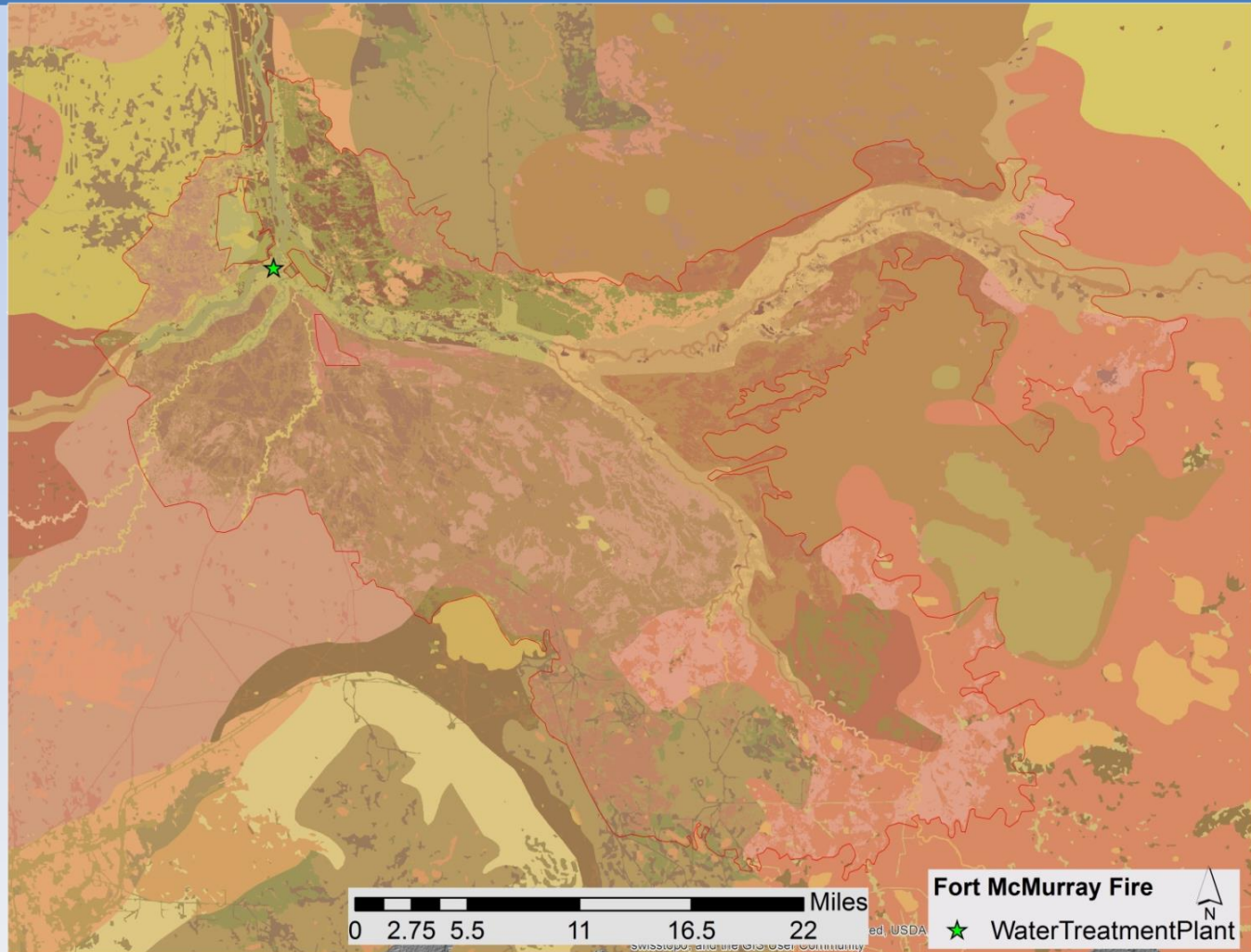
# Canadian Soils



Canadian Soil Landscapes database

<http://sis.agr.gc.ca/cansis/nsdb/slc/v3.2/intro.html>

# Post-fire Soils

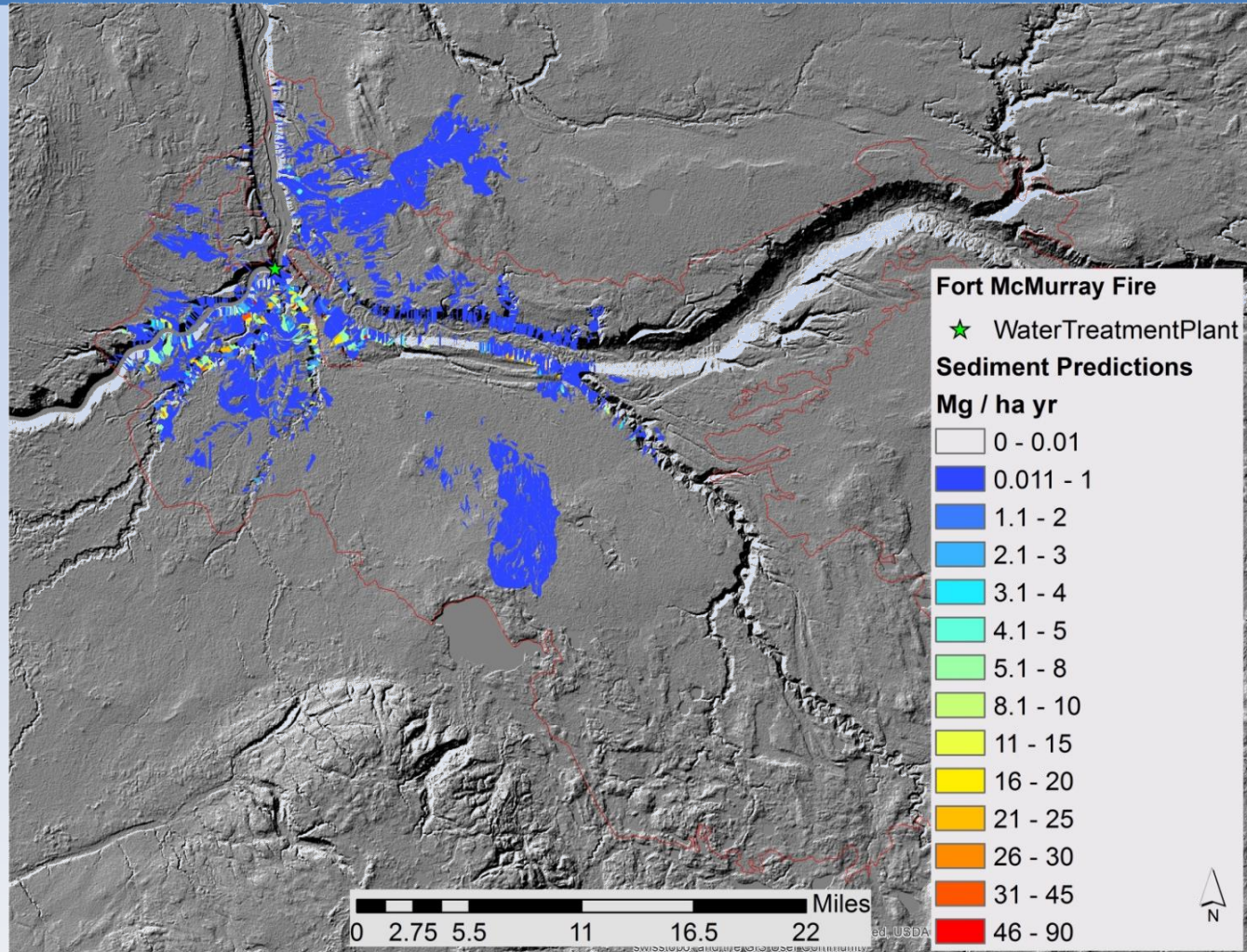


# Climate

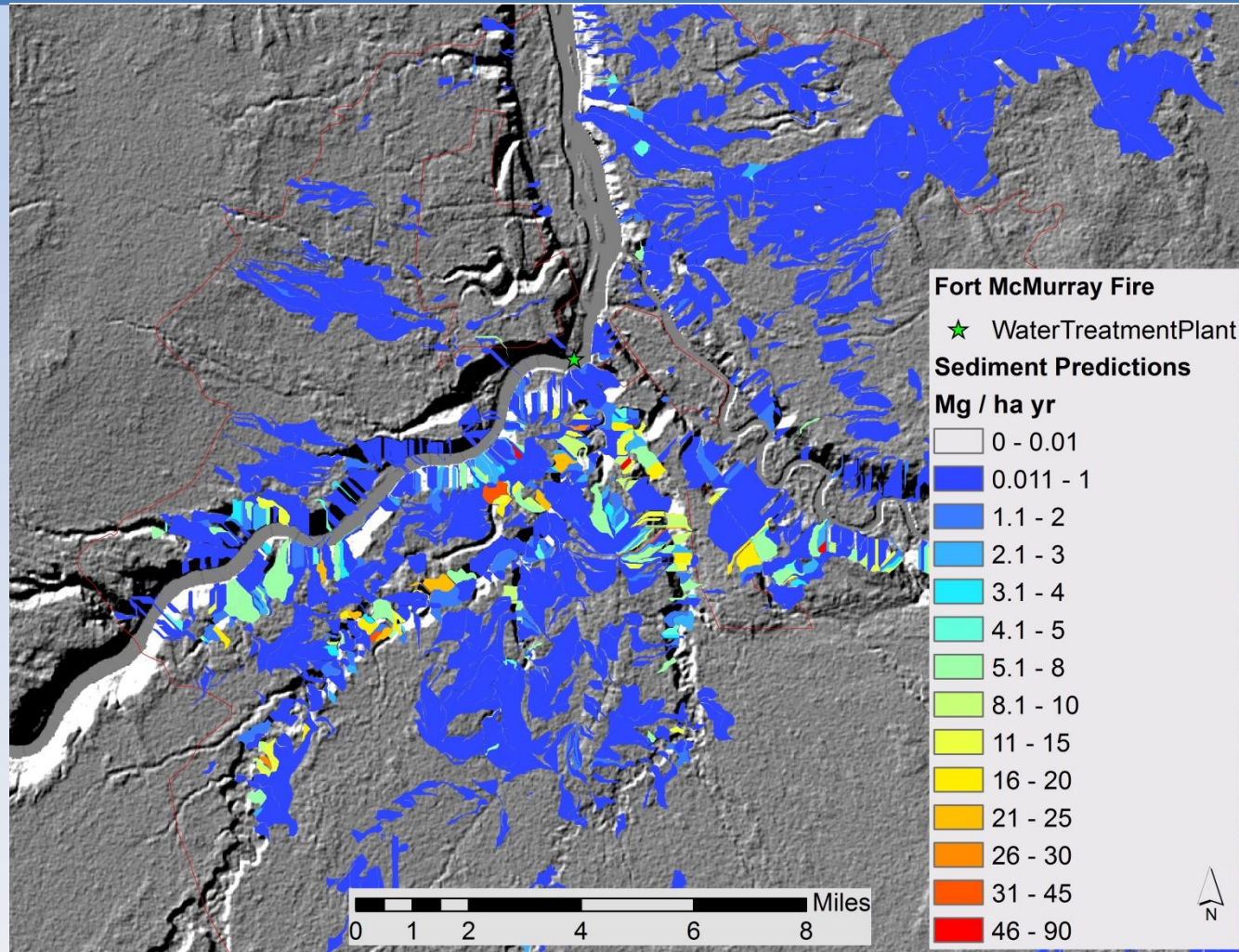
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- For the Fort McMurray fire a 100 year climate file was developed based on nearby weather datasets.
- For the preliminary runs we modeled 5 years of potential first year post-fire weather.
- Average annual precipitation for the modeled 5 years was 31 inches /789 mm.

# Results

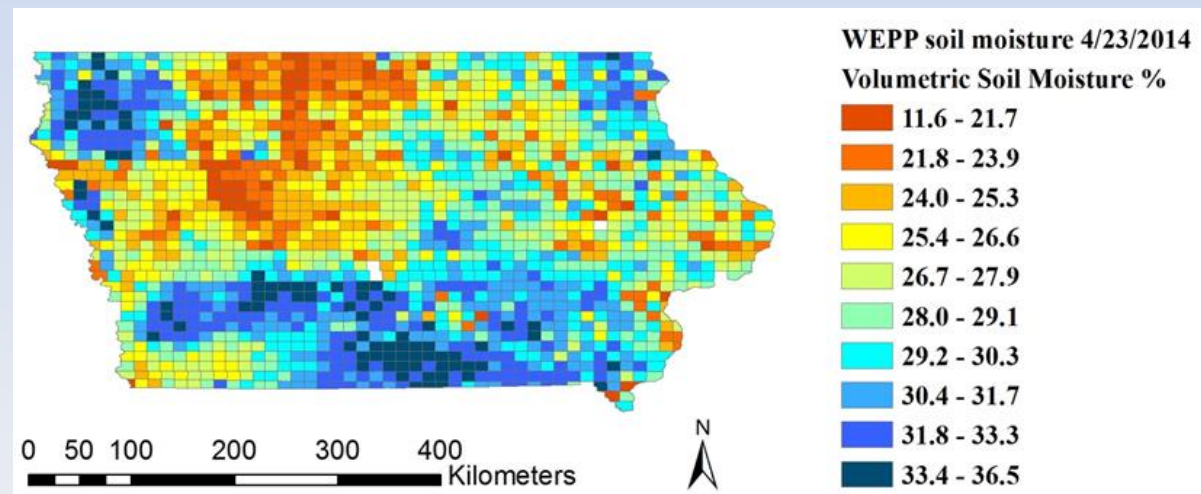


# Results



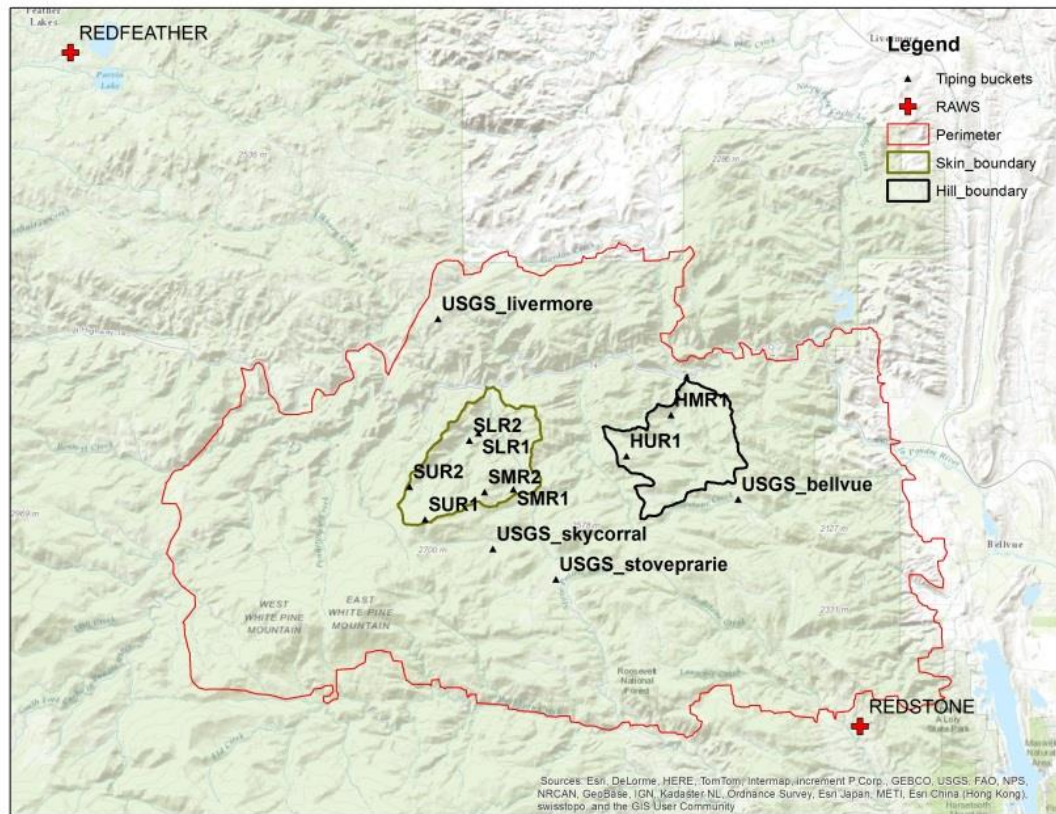
# Future Plans for Fort McMurray

- Francois may build on the modeling to predict ash and fine sediments that could impact the water intake for his PhD dissertation
- May use the site to explore sharpening SMAP and sentinel soil moisture data with hydrological modeling.



*WEPP-predicted volumetric soil water for 4/23/2014 downloaded from the Iowa Daily Erosion Prediction Project (Cruse et al., 2006).*

# High Park Fire Validation

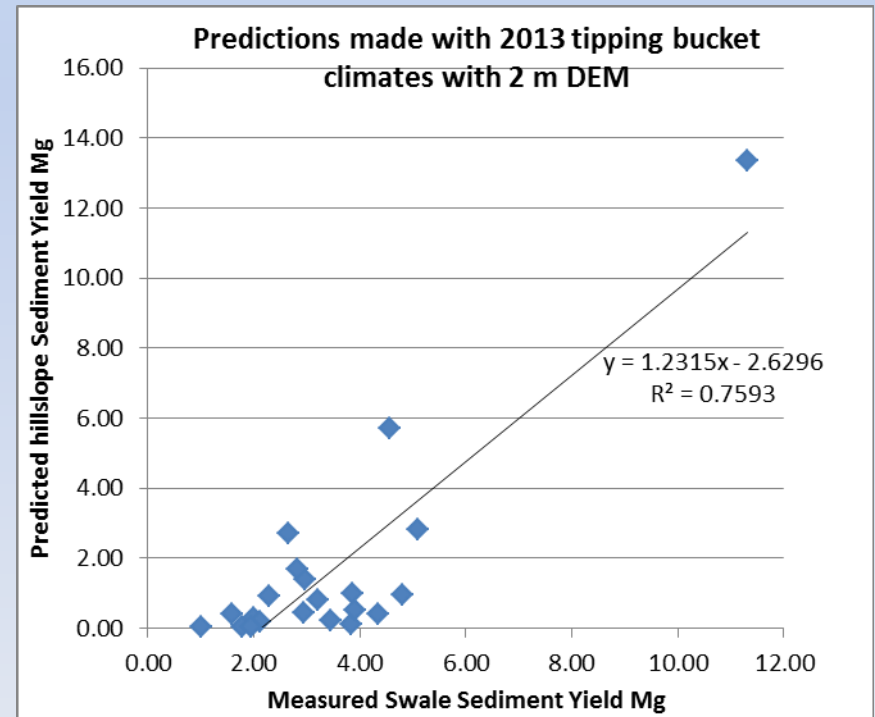
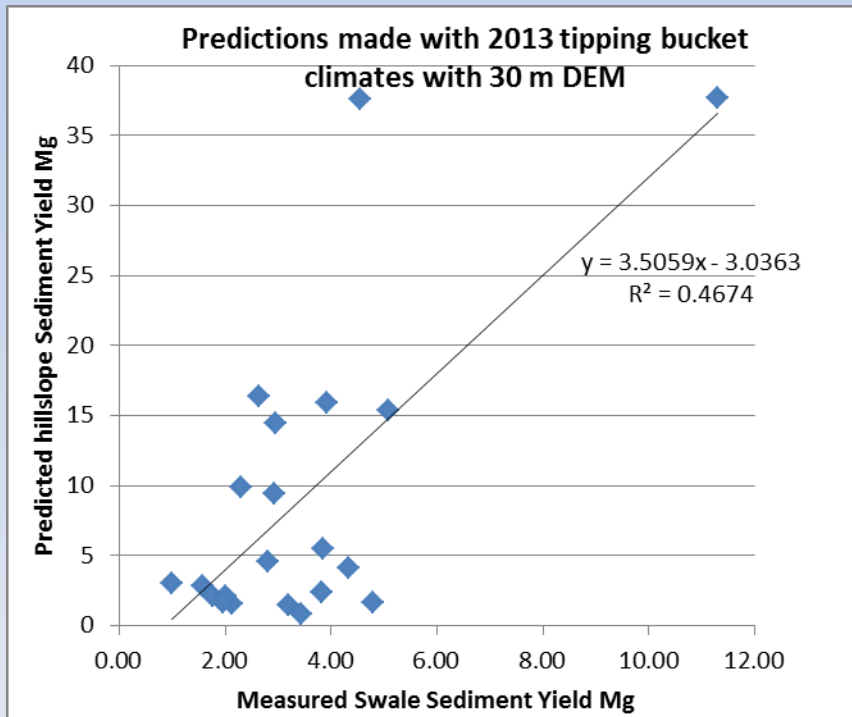


WEPP climate file	2012 precip (in)	2013 precip (in)	2014 precip (in)
Redfeather_Bellvue	8.49	20.02	16.29
Redfeather_HLR1	8.75	22.5	18.38
Redfeather_HMR1	8.92	24.71	19.63
Redfeather_HUR1	8.4	23.14	17.58
Redfeather_Livermore	7.13	13.38	13.96
Redfeather_Masonville	8.09	18.54	14.35
Redfeather_Sky_Corral	8.31	19.84	15.4
Redfeather_SLR1	9.12	26.28	20.33
Redfeather_SLR2	9.27	24.02	18.95
Redfeather_SMR1	9.16	27.12	22.92
Redfeather_Stove_Prairie	8.19	18.86	14.5
Redfeather_SUR1	10.01	14.46	n/a
Redfeather_SUR2	8.56	19.17	15.84



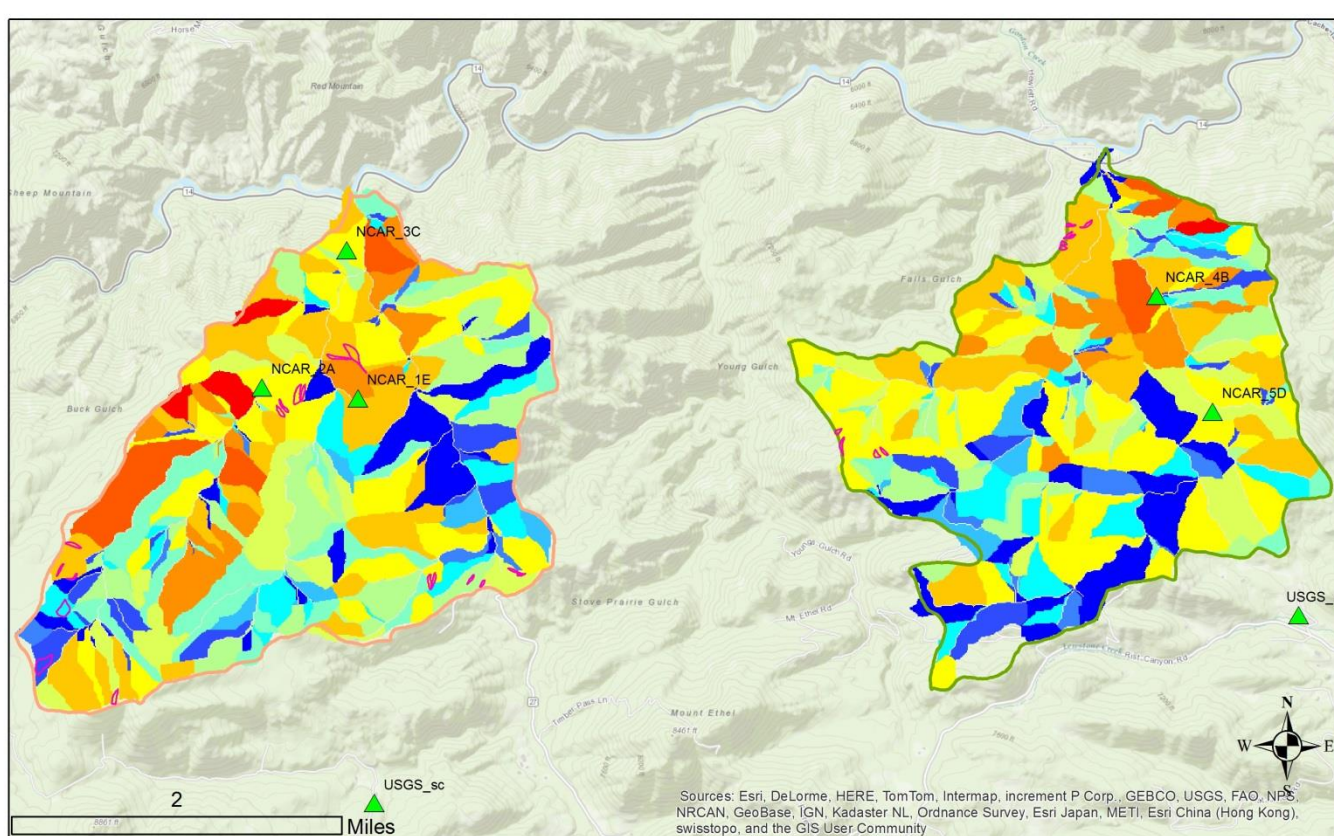
Sediment fence data from CSU:  
 Dr. Lee MacDonald, Dr. Stephanie Kampf  
 Sarah Schmeer

# High Park Fire Validation



Spearman's rank correlation for the BAER storm demonstrated rank order between predictions and observations tended to agree with an alpha of 90%.

# High Park Fire Validation



all\_swales  
Skin\_boundary  
Hill\_boundary

rain\_ncar\_usgs

**Sediment Bellvue**

**2013 Mg/ha**

0  
0.01 - 0.5

0.51 - 1	11 - 15	41 - 50
1.1 - 2	16 - 20	51 - 60
2.1 - 5	21 - 30	61 - 70
5.1 - 10	31 - 40	

# Socioeconomic Impact

## Butte Fire (287 km<sup>2</sup>)

- Butte fire, CA
  - BLM spent more than \$3 million on mitigation treatments, justified and targeted using modeling products made possible by our NASA BAER program (William Haigh, BLM, Personal communication, 6 January 2016).
- King fire, CA
  - USDA Forest Service BAER Team used modeling to target \$1 million in mulching. Model results were used to justify costs of treatments some of which was paid for by the Sacramento Municipal Utility District to protect one of their hydroelectric and water supply reservoirs downstream of the fire (Jeff Tenpas, USFS Region 5, Personal communication, 10 April, 2015).



Photo provided by: Bill Haigh



# Thank you



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Questions?



<http://geodjango.mtri.org/geowepp>